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GENERAL ARTICLE

Reactions to Imagery Generated Using Computational Aesthetic Measures

PRASAD GADE, MARY GALVIN, JAMES O'SULLIVAN, PAUL WALSH AND ÓRLA MURPHY

ABSTRACT

This article examines whether textural generation system imagery evolved with computational aesthetic support can be judged as having aesthetic attributes, both when knowing and not knowing its true origin. Such a generation, depicting a digital landscape, is offered to two groups of participants to appraise. It is hypothesized that there will be no statistically significant difference between the groups on their appraisal of the image. Results from statistical analysis prove to be consistent with this hypothesis. A minority of participants, however, do exhibit significant differences in their perception of the image based on its means of production. This article explores and illustrates these differences.

While there has been much debate on the definition of art, its amorphous nature will always lend itself to a lack of clarity. Our understanding becomes increasingly unclear when we enter debates on the constitution of aesthetic experience. The following research draws on existing literature across psychological, philosophical and scientific approaches to art and aesthetics, with the aim of questioning the role that computer-generated images play in this artistic quagmire. Using an application that we created, we produced a digital image for dissemination to a participant group, along with a survey. Using the data gathered from respondents, we were able to judge their reaction to an image of a computational composition. This reaction was potentially affected by the additional information that was provided with the image. Before the results of this research are explained, it is necessary to discuss the computational composition itself.

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AESTHETIC MEASURES AND EVOLUTIONARY ALGORITHMS

Designing digital artifacts is a time-consuming process that requires both artistic skill and a familiarity with a variety of sophisticated computational techniques. A number of applications exist that can assist designers in the creation of such artifacts, but the use of these tools can require a considerable amount of manual input. This research demonstrates a novel interactive genetic algorithm, coupled with the use of computational aesthetics, which can be used in the evolution of fractal terrains [1,2]. Interactive genetic algorithms are variants of genetic algorithms, where a fitness evaluation is conducted according to user preferences. Traditionally, this method presents some drawbacks, both human and technical: User fatigue can emerge from a loss of interest or patience, or the system may suffer from any element of misguidance during the evaluation phase. To address these issues, we developed a system that uses computational aesthetic measures to direct the evolution of fractal terrains without significant contribution from users. The image offered to participants in this study was a result of using such a system.

The landscape design was rendered using a third-party software component called Terragen. Terragen is a fractal landscape and animation generator, developed by Planetside Software, that creates photorealistic visualization of landscape designs and natural environments including sunsets, clouds, skies and water sceneries with real-time rendering. Terragen reads over 800 parameter values in an extensible markup language (XML) format and generates their graphical representation in the form of an image. Requiring users to set some 800 values to define the properties of a landscape is, as already noted, a complex and time-intensive task. Our interactive tool automatically defined the necessary parameters using machine-learning techniques based on the principles of Darwinian natural selection. It computationally eliminated landscapes with low aesthetic measures and kept those with high aesthetic measures. The novelty in this approach is the combination of aesthetic measures with interactive genetic algorithms as a means of automating

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fractal generations. The evolutionary design of a computational nature proved successful, but interactive genetic algorithms, as automated systems, require aesthetic measures if they are to produce artifacts that satisfy human tastes. Using observation techniques, a host of researchers have refined the aesthetic measures at the heart of this form of computation [3–8]. The automated evolution of digital artifacts has become widespread, not only in the field of vector graphics [9] but in other creative fields as well [10,11].

Our system (Fig. 1) segments the evolution of landscape design as it progresses through the following broad stages: Initialization, Fitness Evaluation, Selection, Genetic Operation and New Population.

In the initial phase, our program creates a set of 16 files with randomized settings, all of which define the properties of the landscape design. Each file is then sent to the Terragen render engine to convert its numerical representation to graphical form. Our system displays the initial population (Fig. 2) before the user enters the desired number of iterations that the software will use to find the most suitable fractal design.

For each population of images in the current step, Fitness Evaluation is performed on generations via a number of methods. The three landscapes receiving the highest scores—based on aesthetic measures—are selected as suitable; the remaining landscapes are marked as degraded. Users may, at their discretion, rank landscapes based on their own preferences, but in an effort to make this process as intuitive as possible, we allowed aesthetic measures to dictate decision-making.

Users may elect to apply computational measures based on global contrast factors, or on Kolmogorov complexity, or, alternatively, through a mean value of both fitness scores, calculated using the following equation:

$$GCF\_Score = \frac{(GCF_V - Score_{min}) * (Score_{Max} - Score_{min})}{(GCF_{Max} - GCF_{min})}$$

$$K\_Score = \frac{(K_V - Score_{min}) * (Score_{Max} - Score_{min})}{(K_{Max} - K_{min})}$$

$$\Rightarrow TotalScore = \frac{GCF\_Score + K\_Score}{2 * (Score_{Max})}$$

Of the three generations considered most pleasing, two are chosen on the grounds of a probabilistic selection process that is biased toward the landscape definitions marked as having high aesthetic values. In the Genetic Operation phase, the selected terrains are recombined to produce a new population. This recombination technique is based on computational models of genetic processes. During the recombination process, information is exchanged between highly rated definitions, producing new sets of numerical representations. After performing the genetic processes, a new set of 16 generations is rendered and sent to the user interface for further evaluation. The entire process is then repeated until either the user is satisfied or a predetermined number of generations have been produced. For the purpose of this research, an image was taken from such a predetermined list of generations (Color Plate A).

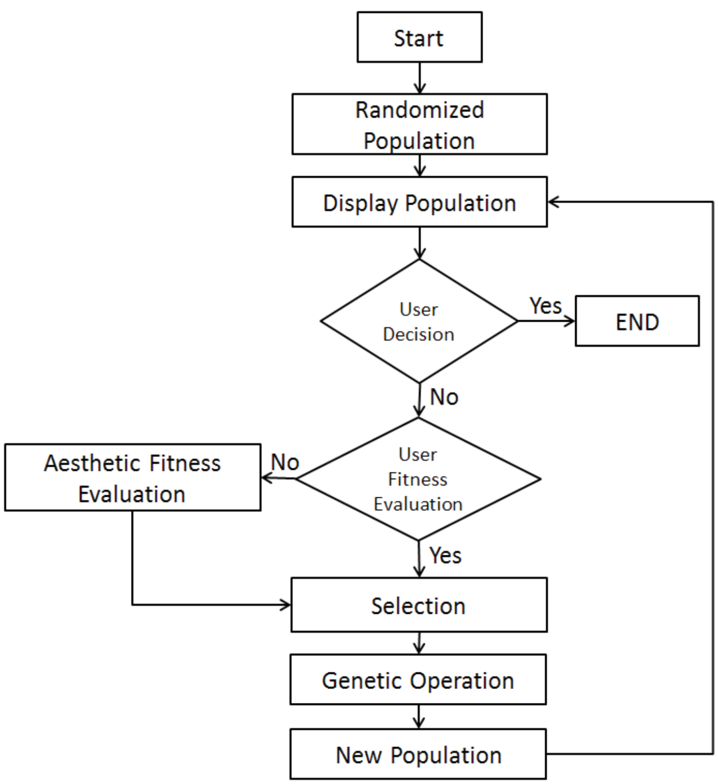

Fig. 1. Evolution of landscape design. (© Gade et al.)

Responding to Aesthetic Potential

The purpose of this article is not to enter into an exchange on the nature of art. We are not seeking to justify whether this image could be classified as art from a purely theoretical perspective but rather to offer a snapshot of how an audience might perceive the work. In this context, it was the participants' responses that were of interest when different information was attached to the same image regarding its origin. The focus was on the aesthetic attributes of the generated landscape rather than the promotion of it as a piece of art. Most aesthetic experience lingers on the "fringe of human consciousness but it can come into focal awareness under appropriate circumstances, such as . . . when one's attention is directed to aesthetic response by context . . . or when one is given explicit instructions to do so" [12]. This was precisely what occurred. The digital landscape was offered to the participants as something to appraise.

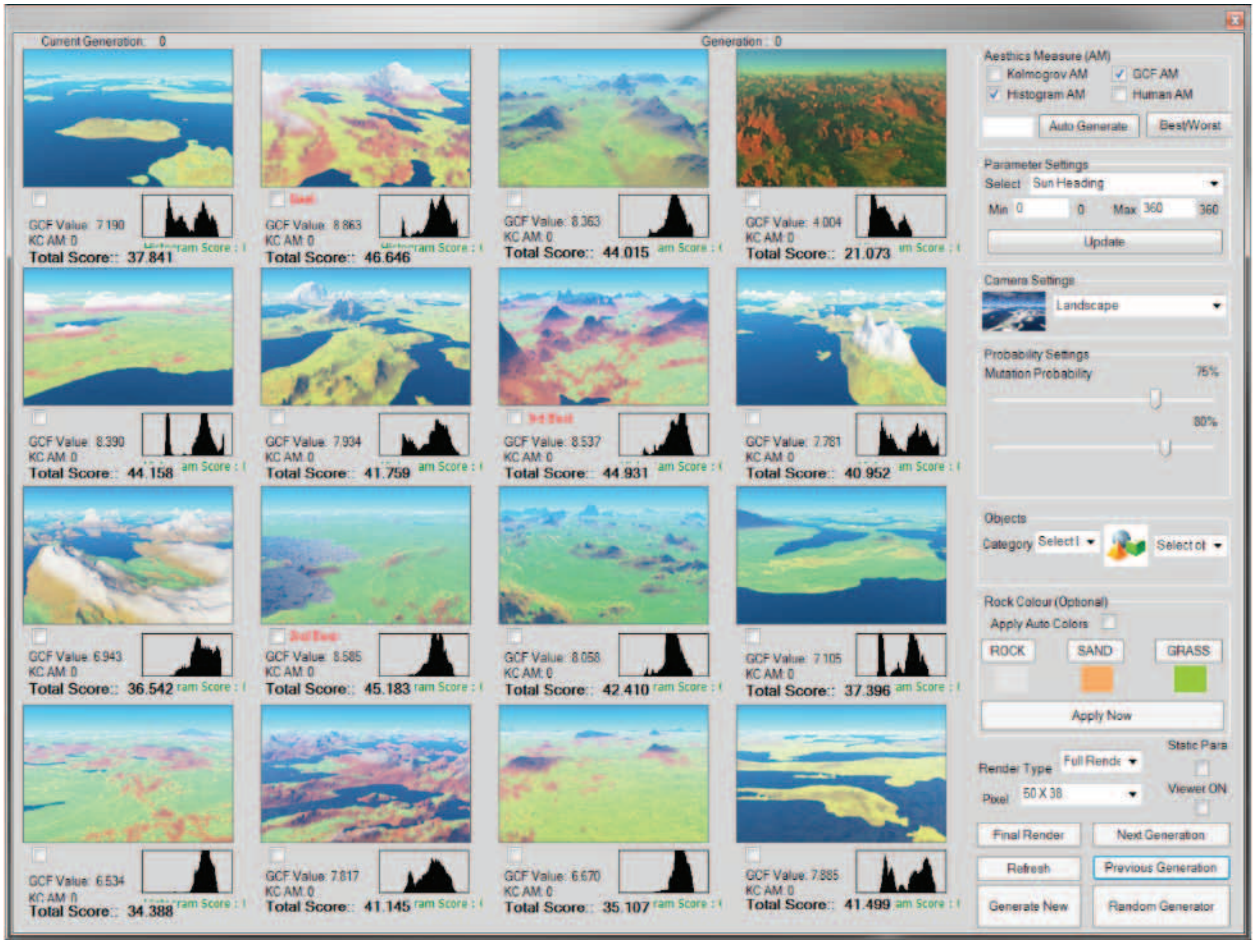

Fig. 2. The initial population before the user enters the desired number of iterations. (© Gade et al.)

Framing for Artistic Appreciation

Aesthetic experience is not always positive and "can include unpleasant as well as pleasant feelings" [13]. Palmer, Schloss and Sammartino considered aesthetic experience as a stand-alone entity and proceeded to advocate the scientific study of aesthetic response [14]. They argued that aesthetic experience is ubiquitous in our daily lives and something we are constantly subjected to when interacting with our environment, "whereas art is limited to the subset of human artifacts intended to be viewed as art, whether in a museum, a gallery, or one's own living room" [15]. They stated that, as humans, we bear witness to many ineffable moments of visual stimulation, but it is not until we capture those moments in frame, through various mediums, that they can be considered suitable for artistic appreciation.

This was the intent of our research—to make a digital landscape that could be framed for suitable appreciation. In 2011, Lindell and Mueller sought to determine whether science can account for taste by studying the psychology of art appreciation [16]. They adopted a cognitive approach, distinguishing bottom-up and top-down contributing factors. Of particular interest are their top-down factors—prototypicality, novelty and additional information. The image used in this study was predetermined as a landscape, which meant that bottom-up factors were out of our control, whereas the top-down factors could be manipulated. We tried to find a *different enough* image to avoid depicting a *too-accurate*, perhaps photograph-like, representation of a landscape, running the risk of being too boring to be appreciated artistically [17]. Dewey's distinction between perception and recognition in our everyday experience of material objects supported this notion:

> Recognition is when we experience a thing and interpret it only as something we already know. The act of recognition may be conscious or unconscious . . . it does not produce a new organization of feeling, attention, or intentions. Many people relate to objects through recognition simply because of habituation, or because they are unable to give their full attention to all of the information received from the environment. . . . Perception, on the other hand, occurs when we experience a thing and realize its own inherent character . . . [18].

The object composes certain qualities on the viewer that create new insights, which is what makes any experience aesthetic in Dewey's perspective.

In this case, a representation of a landscape might be an image to which we are habituated, so an effort was made to make it stand out, to give it "its own inherent character."

The Tapestry

The creator of this piece is an Irish man based in Toronto, Canada. When he was in his late twenties, he was forced to leave Ireland due to the economic climate that was facing him here. Now in his early thirties, he has managed to establish a modest business in Toronto, based around his passion and expertise in the creation of digital and corporeal artifacts. This piece, he has entitled *The Tapestry*. He associates this piece with his place of birth and the skill that he has acquired throughout his career woven through it.

Fig. 3. Scenario given to Group 1. (© Gade et al.)

This was achieved through the additional information that we offered with the image. Lindell and Mueller drew on Russell's 2003 paper, "Effort after meaning and the hedonic value of paintings," by arguing that a large part of positively experiencing a piece of visual art consists in grasping or understanding the intended meaning of the work [19]. They posited that much of a work's meaning is provided by its title, which gives insight regarding the composer's intended meaning and hence aids interpretation. Therefore, Group 1 was offered the image under the title of *The Tapestry*. Russel also noted that additional information about the artist and his or her work would increase a viewer's positive experience with the image [20]. This gave rise to questions about whether different information supplied with the same image would invoke different responses in appreciation of the piece. Responding to this, the information provided in Fig. 3 was supplied alongside the image. Jucker and Barrett (2011) also offered an inadvertent provocation regarding our evolutionary art algorithm being regarded as a tool or as an artist:

> A tool will be recognised as such if it carries out a specific function; and if this tool carries out this function, we directly infer that its maker intended to do so. This tool, then, may be assessed without speculation regarding the maker's intention. . . . For a work of art, the contrary is true: as it carries out no obvious precise function, it cannot be assessed without speculation about the artist's intention. In other words, a work of art would be assumed to communicate something, which would have to be inferred from the artist's intention [21].

In this context, we were not interested in how well the computational aesthetic measures generated fractal imagery but instead in how the image was perceived. Participants may or may not have perceived the landscape as artistic. What was of interest was whether their perception was influenced by their understanding of the landscape's origin.

METHOD

Participants

A total of 122 participants were recruited through convenience sampling. They were associated with one or more of the following groups: IEEE Computer Society; IEEE Society on Social Implications of Technology; Tech Plus LinkedIn Group; teaching faculty at Cork Institute of Technology; College of Arts, Celtic Studies and Social Science at University College Cork; researchers in Digital Arts and Humanities at various international institutions; and Applied Psychology graduates at University College Cork.

Materials

The stimulus material was a questionnaire (Fig. 4), which included 20 questions based on a Likert scale of 10 items (the responses ranging from Strongly Disagree, 0, to Strongly Agree, 10). The questions were based upon—and also accompanied by—the image generated by the algorithm (Color Plate A).

Design

The dependent variable being measured was the score the participants assigned to each statement, representing their appraisal of the piece. The independent variable was the information provided with the image, which represented the true nature of the image and a manipulated piece of information alluding to an alternative story behind it. This story offered the participants a title for the piece (*The Tapestry*), a bio of the artist who created it and an explanation of the intent behind it (Fig. 3). A Paired Sample T-Test was carried out on the responses of Group 1 (122 participants who received both conditions), as well as an Independent Groups T-Test between Groups 1 and 2 (Group 2 consisted of 23 participants who were exposed only to the true condition of the piece).

Procedure

Participants in Group 1 were asked to complete the survey on the basis of the manipulated information. Having completed the survey, they were then informed of the true origin of the image. At that stage, the participants were asked if this disclosure incited them to change their opinions of the piece. If so, they were given the option of doing the survey once again, allowing them to change their responses accordingly. If they chose not to change their responses, this concluded their participation in the experiment. Group 2 was presented with the same set of statements and image, but from the beginning the participants were provided with only the true condition of the piece. In this case, the additional information did not contain any title, bio or artistic intent. Instead it contained an explanation of how the algorithm created the

1. I would describe the creator of this piece as an artist.
2. I understand what the creator was trying to achieve.
3. I find this piece visually pleasing.
4. (Regardless of answer to question 3) I would consider this to be a piece of art.
5. I can relate to this piece.
6. I associated a memory with this piece.
7. I would hang this piece on my wall at home.
8. I would hang this piece on the wall in my workplace.
9. I would use this piece as a screensaver on my laptop.
10. I would purchase this piece.
11. I would like to create a piece like this myself.
12. I feel confident that I could create a piece like this myself.
13. I would give this piece as a present to a loved one.
14. Using digital tools to create art is not art.
15. Computers cannot create art.
16. When I look at this piece, it evokes certain emotions within me.
17. I would like to see more work from this exhibition.
18. I like to work hard at interpreting a piece of art.
19. Beauty is in the eye of the beholder.
20. A rose by any other name would smell as sweet.
    [At this stage, the true origin of the image is revealed to the participants.]
21. Having this information, I would review the answers I have just given.

Fig. 4. The stimulus material: a questionnaire. (© Gade et al.)

```
The above image was generated using a
technique based on evolutionary algorithms,
where a computer generates digital
artefacts automatically by allowing users
to direct an algorithm towards desired
output, without requiring any specialist
expertise. We have implemented such a
technique for generating landscape designs
using an interactive genetic algorithm
(Walsh and Gade, 2010). Interactive genetic
algorithms are extended versions of genetic
algorithms, where a fitness evaluation is
conducted according to user preferences.
    For the purpose of this research,
our landscape designs were rendered
using a third-party software component,
Terragen. Terragen is a fractal landscape
and animation generator, developed
by Planetside Software, that creates
photorealistic visualization of landscape
designs and natural environments including
sunsets, clouds, skies and water sceneries
with real-time rendering. Terragen reads
in excess of 800 parameter values in
an extensible markup language (XML)
format, and generates their graphical
representation in the form of an image.
Requiring users to set some 800 values to
define the properties of a landscape is a
complex and time-intensive task.
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Fig. 5. True scenario given to Group 2. (© Gade et al.)

artefact (Fig. 5). The presence of Group 2 was to control for any participants who chose not to complete the survey again in Group 1, even though they had changed their minds.

RESULTS AND DISCUSSION

Analysis of the results revealed attitudes toward artistic scenery generated using computational methods.

Paired Sample T-Test

Out of 122 participants, only 25 (20 percent of the participants) desired to change their answers after being told the true nature of the image. This result supported the stated hypothesis in that the means of production did not affect the final appraisal of the landscape.

Based on the 25 participants who *did* choose to review their answers, a Paired Sample T-Test (Table 1) was conducted to evaluate the influence that the process of production had on the participants' scores. There were statistically significant decreases in 13 questionnaire items between the initial responses provided in the first condition and the final responses provided in the second. In order to understand this change of opinion, it was necessary to highlight those particular statements individually. This allowed for the grouping of certain statements together.

The first grouping was directly related to perceiving the artefact as a work of art (statements 1, 2 and 4—*I would describe the creator of this piece as an artist, I understand what the creator was trying to achieve* and *I would consider this to be a piece of art*). Here the data suggested that once participants discovered that the image was based on an algorithm, they significantly changed their opinion of the *who* behind the work being considered an "artist." The level of understanding expressed by the participants also dropped in relation to the intention of the image. Similarly, the participants considered the image a piece of art only when they associated a traditional artist with its production; the algorithm lowered the potential of the piece to be considered "artwork."

Statements 5 and 6 (*I can relate to this piece* and *I associated a memory with this piece*) both alluded to how participants related to the image. Initially, in both answers, the participants expressed a certain level of relation. This dropped significantly, however, when they discovered that the image was computer generated, removing themselves from the intimate interaction between observer and piece.

Statements 7–10 (*I would hang this piece on my wall at home, I would hang this piece on the wall in my workplace, I would use this piece as a screensaver on my laptop* and *I would purchase this piece*) related to the overall aesthetic experience of the image. While these scores dropped in the second condition, it is worth noting that the initial scores—even for those who did not change their mind—were not that high. For these items, the participants were answering based on whether they enjoyed looking at the piece or not. These results were of interest as they raised questions around the image used and not necessarily the algorithm. If the image were not a landscape, would the results have been higher?

What was interesting about statement 17 (*I would like to see more work from this exhibition*) was that when participants believed a traditional artist to be behind the image, they were more inclined to view more of the artist's work. However, the scores then dropped, suggesting that the work itself was only interesting to them, or maybe worth committing to, based on the process of its production. This offered a reminder that overall, the participants did not find the piece particularly aesthetically pleasing, but even so, they would still have been willing to see more from the artist. Their willingness to *try out* more images from the algorithm was not present.

Statements 19 and 20 (*Beauty is in the eye of the beholder* and *A rose by any other name would smell as sweet*) were the most ambiguous on the questionnaire because they were not directly related to the image. What was interesting was that participants' opinions changed significantly based on the manipulation of the questionnaire. While the scores still seemed to represent agreement, there was a decrease resulting from the questioning of how art is produced. There were six questions that did not change significantly between the two conditions (statements 11, 12, 14, 15, 16, 18). In general, these statements scored means that were significant with agreement in both conditions, with the exception of statement 12 (*I feel confident that I could create a piece like this myself*).

Independent Samples T-Tests

An Independent Samples T-Test was conducted (see supplemental Appendix A; appendixes provided with online version of this article) to compare the scores of the participants who received only the true condition (Group 2) with those who were manipulated in the first condition but who did not feel it necessary to change their opinions (Group 1). The intention was to counteract any participants' disinclination to redo the questionnaire, even if they had changed their minds in the second condition. There was a significant difference between Groups 1 and 2 for statements 1, 2 and 4 (*I would describe the creator of this piece as an artist, I understand what the creator was trying to achieve* and *I would consider this to be a piece of art*). These results proved to be consistent with the results from the Paired Sample T-Test above. However, statements 12 (*I feel confident that I could create a piece like this myself*) and 16 (*When I look at this piece, it evokes certain emotions within me*), which proved significant in this t-test, did not in the above Paired Sample T-Test.

An Independent Samples T-Test was also conducted (Appendix B) to compare the scores of the participants who received the questionnaire in the true condition (Group 2) with those who received the truth after receiving the manipulated information and who felt it necessary to change their responses (Group 1). There was no significant difference between groups for any of these scores, thus illustrating consistency with the results on the Paired Sample T-Test.

TABLE 1. Results from Paired Sample T-Test. (© Gade et al.)

Pairing of Questions	Mean	Std. Deviation	t	df	Sig. (2-tailed)
Q1–Q22	4.00000	2.78193	7.044	23	.000
Q2–Q23	2.26087	2.63227	4.119	22	.000
Q3–Q24	.61905	1.35927	2.087	20	.050
Q4–Q25	2.40909	2.36359	4.781	21	.000
Q5–Q26	1.13043	2.00691	2.701	22	.013
Q6–Q27	1.04348	1.58051	3.166	22	.004
Q7–Q28	1.21739	1.08530	5.380	22	.000
Q8–Q29	.91304	1.04067	4.208	22	.000
Q9–Q30	.95652	1.10693	4.144	22	.000
Q10–Q31	.86957	1.05763	3.943	22	.001
Q11–Q32	.81818	2.34290	1.638	21	.116
Q12–Q33	–.57143	2.65653	–.986	20	.336
Q13–Q34	1.18182	1.40192	3.954	21	.001
Q14–Q35	–.90909	3.61095	–1.181	21	.251
Q15–Q36	–.68182	3.18309	–1.005	21	.326
Q16–Q37	.72727	1.95623	1.744	21	.096
Q17–Q38	1.27273	2.31315	2.581	21	.017
Q18–Q39	.27273	1.80428	.709	21	.486
Q19–Q40	.45455	1.01076	2.109	21	.047
Q20–Q41	.77273	1.41192	2.567	21	.018

CONCLUSION

In a review of Shimamura's *Experiencing Art in the Brain of the Beholder* [22], Hutton and Kelly (2013) discuss Shimamura approaching "the art history and scientific discourse within them with the sort of cross-disciplinary surface-skimming that only adds fuel to the fires of contemporary academic turf battles" [23]. We realize how loaded and perhaps volatile tackling this research can be. In general, the majority of participants appraised the generated landscape positively, regardless of its origin. Where there were significant differences, they were based on the additional information offered to the participants, rather than on the appraisal of the visual stimulus. Overall, the results proved consistent with the hypothesis: Textural generation system imagery evolved with computational aesthetic support can be judged as having aesthetic attributes, both when knowing and not knowing its origin.

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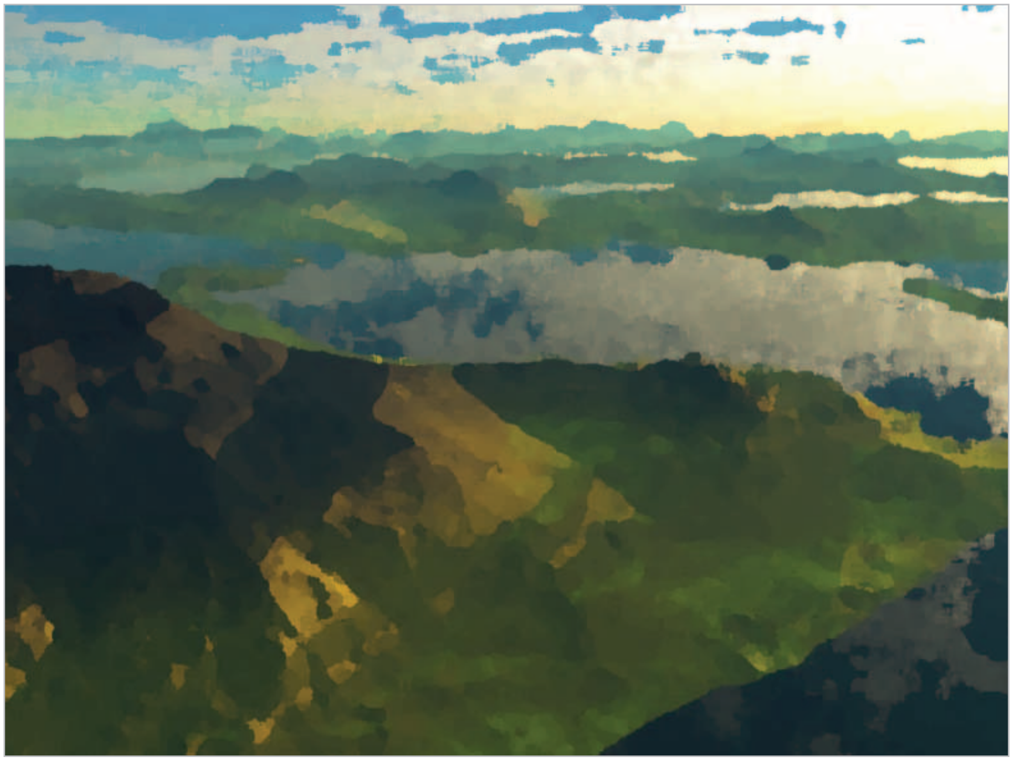
COLOR PLATE A: **REACTIONS TO IMAGERY GENERATED USING COMPUTATIONAL AESTHETIC MEASURES**



A digital landscape image created by a textural generation system that evolved with computational aesthetic support. (© Gade et al.) (See article in this issue by Prasad Gade et al.)